# PATRIOT PAC-3 MISSILE (PAC-3)

**DoD ACAT ID Program**

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|---|---|
| Total Number of Systems: | 36 Tactical Fire Units |
| Total Program Cost (TY$): | $7778M |
| Average Unit Cost (TY$): | $91.14M |
| Full-rate production: | 1QFY04 |

**Prime Contractor**

Raytheon
Lockheed Martin Vought Systems

## SYSTEM DESCRIPTION & CONTRIBUTION TO JOINT VISION 2010

The PATRIOT is an air-defense, guided-missile system originally designed to counter the air-breathing threat of the 1990s and beyond. Two modifications, PATRIOT Advanced Capability 1 and 2, were added to provide a limited capability for defense against tactical ballistic missiles. The key features of the PATRIOT system are the multifunctional phased-array radar, track-via-missile guidance, and extensive modern software and automated operations, with the capability for human override.

The PATRIOT Advanced Capability-3 (PAC-3) growth program is being implemented through a series of three stand-alone fielding configurations. Configurations 1 and 2 have been fielded. Each configuration consists of a grouping of materiel-change packages and a software upgrade called a post-deployment build, which includes a collection of software product upgrades. These improvements contribute to ***Joint Vision 2010***, and relying on ***information superiority*** and ***technological innovation***, will specifically: (1) be active measures to achieve ***precision engagement***; (2) permit PAC-3 to fully

support the lower-tier theater air and missile defense mission; and (3) contribute to ***dominant maneuver*** by our forces and ***full-dimensional protection*** for both forces and facilities.

Configuration 1 consists of: (1) an expanded weapons control computer; (2) optical disk drives; (3) an embedded data recorder; and (4) implementing software. These upgrades provide four times greater computer throughput and a more efficient data recording and retrieval capability. Configuration 1 also includes the hardware associated with Radar Enhancement-Phase II, which incorporates a dedicated pulse-Doppler processor.

Configuration 2 includes the Communication Enhancements Phase I, which is a materiel-change package that provides improved external communications (to the PATRIOT battalion), and includes linkage into the Theater Missile Defense (TMD) architecture. Configuration 2 software improvements include: (1) a counter anti-radiation missile capability to minimize vulnerability to those missiles; (2) Classification, Discrimination and Identification-Phase I to improve the Tactical Information Broadcast System interface; and (3) a software implementation of Radar Enhancement Phase II.

Configuration 3 consists of: (1) three materiel change packages; (2) the PAC-3 missile; and (3) three software improvements. The three materiel-change packages are: (1) Radar Enhancements-Phase III, which provides significant improvements in system performance; (2) Classification, Discrimination and Identification-Phase III, which provides a high-range resolution radar capability; and (3) a Remote Launch/Communication Enhancement Upgrade to provide the capability to deploy missiles launchers at remote launcher farms, and improve intra-battalion voice and data communications. The PAC-3 is designed to provide hit-to-kill lethality against high-speed tactical ballistic missiles; maneuvering tactical missiles; low-radar cross-section, long-range targets in operational environments; cruise missiles; and other air-breathing aircraft. The three software improvements are: (1) PATRIOT and THAAD interoperability, which optimize the warfighting capability of PATRIOT and THAAD; (2) Joint TMD interoperability, which provide the capability to receive and transmit tactical ballistic missile-related data in a joint-Services environment; and (3) Launch Point Determination to calculate tactical ballistic missile launch points.

## BACKGROUND INFORMATION

Subsequent to Desert Storm, the PAC-3 Operational Requirements Document (ORD) was developed to provide focus for several already planned improvements, plus additional improvements to include a new missile capability. The ORD identifies additional performance requirements needed to counter advanced stealth technology, advanced electronic countermeasure techniques by air-breathing targets, unmanned remotely piloted vehicles, anti-radiation missiles, tactical air-to-surface missiles, and tactical ballistic missiles. The ORD requires that the PAC-3 system be rapidly deployable, robust in firepower, tactically mobile, survivable, low-in-force-structure demands, and able to interoperate with other TMD systems.

Each materiel change package is tested individually and then re-tested as part of a fielding configuration during integrated system testing. Operational testing prior to FY99 included Configuration-2 FOT&E (FOT&E-2), successfully conducted at White Sands Missile Range, NM, and Ft. Bliss, TX, during May and June 1996. The FOT&E-2 consisted of tests using the hardware-in-the-loop Flight Mission Simulator, battalion-level field exercises, and a multiple simultaneous engagement live missile-firing exercise. The live fire test involved a simultaneous engagement by two PAC-2 missiles against a simulated ballistic missile target (a PATRIOT missile) and an air-breathing target (an

MQ-107). The MQ-107 was successfully intercepted. The PATRIOT target self destructed before the PAC-2 missile could intercept it. FOT&E-2 evaluated the Configuration 2 (and Configuration 1) materiel-change packages and software improvements. An Operational Assessment based on FOT&E-2 was completed in August 1996. In September and December 1997, controlled non-intercept flights of the PAC-3 missile, DT-1 and DT-2, were also successfully conducted.

The PAC-3 program has an approved Y2K management plan in effect. System prime contractors have completed certification for Y2K compliance using the DoD checklist. The fielded PATRIOT weapon system makes no significant use of date. Weapon system interfaces, except for the interface to the Global Positioning System (GPS) via the Precision Lightweight GPS Receiver, do not pass date information. Although it uses a two-digit date, the interface does not appear to have a problem. This interface compatibility issue will be examined further during system testing phases. In areas where commercial software are used, especially in the UNIX Operating System or processors (e.g., the classroom trainer), there are some problems with Y2K. Workarounds have been established to respond to these situations.

## TEST & EVALUATION ACTIVITY

There was no dedicated OT conducted in FY99. The FY99 DT of PAC-3 emphasized final system integration in preparation for Force Development Test and Evaluation and ground equipment Limited User Test (LUT). Phase 2 of Configuration 3 Developmental Test and Evaluation (CDT&E) was conducted May-August 1999, and focused on evaluating enhancements to the ground portion of the system (namely the Post Deployment Build-5 software, Radar Enhancement Phase-3, Classification Discrimination Identification-3, and Remote Launch/Communication Enhancement upgrades). These tests did not include flight testing. However, in December 1999, the first of three flight tests was successfully conducted to check the backward compatibility of the ground system upgrades to the currently fielded missiles. A PATRIOT production missile successfully intercepted a Lance missile. When completed, these three tests will include a PAC-2 versus a Lance target, a Guidance Enhanced Missile against a cruise missile surrogate target, and a non-intercept flight of a PAC-2 missile from a PAC-3 launcher.

Flight testing of the PAC-3 missile continued with the successful intercept of a HERA TBM target during the Seeker Characterization Flight (SCF) on March 15, 1999. The primary mission objective of the SCF was to collect data to reduce risk for the DT-3 flight (and the subsequent missile flight program). Test objectives included checking target acquisition and tracking, PAC-3 missile seeker performance during a TBM engagement, and data collection/analysis of target profiling during terminal homing. The PAC-3 Overarching Integrated Product Team (OIPT) reviewed the results of the SCF and approved it as a "successful intercept." The OIPT also determined that the SCF qualified as one of the two intercepts required by Congress before LRIP funding could be obligated to contract.

DT-3 was successfully conducted on September 23, 1999. With the exception of the target reentry vehicle (RV), the design of DT-3 was identical to the SCF. The target for the SCF contained simulated chemical submunitions. The DT-3 RV was a simulated bulk chemical warhead. Data reduced and analyzed indicate the PAC-3 system tracked, engaged, intercepted and destroyed the target. Both the SCF and DT-3 were conducted with prototype hardware and software configurations and non-tactical seeker software. Additionally, the targets were not fully threat representative, since the seeker software had not matured to achieve threat level performance. However, post flight simulations using the tactical seeker software indicated a good probability of success against threat representative targets.

DT-4 was scheduled for December 1999. It was deferred, however, after pre-flight hardware-in-the-loop testing revealed an unexpected target radar cross-section return signal that the seeker software was not yet ready to accommodate. The flight test program will move on to execute DT-5 in January 2000, and DT-4 objectives will be investigated elsewhere in the flight test matrix.

The LFT&E program planned in the TEMP was revised to eliminate the sub-scale, full-body interceptor sled tests. Development of a sub-scale, full-body interceptor was cancelled in FY99. The purpose of sub-scale sled testing was to assess the contribution of the rocket motor to lethality (analyses indicate that the rocket motor will only contribute to lethality in a very small number of potential tactical intercepts). Subsequent hydrocode analyses indicated that the rocket motor makes a significant contribution to missile lethality in that small percentage of intercepts. Fourteen of fifteen full-scale sled tests against unitary and submunition chemical, high-explosive submunition, nuclear, and biological submuntion targets have been completed. The remaining test, replication of the DT-6 flight test, is planned for the spring 2000. The sub-scale light-gas gun test program, completed during FY99, produced test data at higher velocities (3 km/sec) than sled track (1.7 km/sec). The LFT&E program should be completed before the end of FY00.

## TEST & EVALUATION ASSESSMENT

The most current TEMP was approved by OSD on November 1, 1996. This TEMP is in need of revision since the flight testing program is undergoing some significant changes from the one in the approved TEMP. That TEMP requires production representative missiles throughout the DT and OT flight test program. Slower than expected software development and unexpected hardware problems resulted in the need to use non-production representative hardware and software in the test program. This, coupled with relocation of the seeker assembly facility from Georgia to Alabama and the need for temporary “white wire” fixes in the seeker circuitry, resulted in testing a missile that is not considered production representative. Using these non-production prototype missiles in testing does not adequately address the suitability and effectiveness issues for the final production missile configuration. Additionally, cost growth and schedule slips are driving BMDO to recommend that the PAC-3 User defer testing of non-theater ballistic missile capabilities (aircraft and some cruise missiles). At the encouragement of DOT&E, BMDO is considering continuing with annual Low Rate Initial Production options after Milestone III, until adequate follow-on testing is completed on fully production representative missiles and against User requirements where testing was deferred.

Technical tests conducted in FY99 served to minimize risk by finding and fixing problems prior to actual procurement of the Configuration 3 upgrades. Results of the developmental tests of Material Development and Post Deployment Build-4 software indicate that PAC-3 is progressing satisfactorily; however, development of Post Deployment Build-5 software remains slightly behind schedule in meeting its system-level performance and suitability requirements.

All Material Change Package hardware and its implementing software, as well as the PAC-3 missile will undergo performance verification testing during the integrated system LUT (2QFY00) and IOT&E (FY01). Extensive use of modeling and simulation supports both the DT and OT evaluations. Both DT and OT objectives are combined, where possible, to minimize testing.

With the successful execution of the DT-3 intercept mission, the PAC-3 system has completed two successful engagements against limited threat representative targets, and demonstrated system performance and battlespace requirements via available computer and hardware-in-the-loop simulations. However, CDTE-3 continues to reveal significant system problem areas. Some of these areas include

interoperability, counter anti-radiation missile capability, and reliability/availability/maintainability. Failure to resolve these problems may result in a continued slip in the start of LUT (and IOT&E). Flight intercept velocities are difficult to accomplish in ground based testing. However, because sled track and light gas gun targets can be extensively instrumented and photographed, and because debris from those events can be recovered and examined, detailed estimates of lethality can be evaluated. Flight testing produces much more realistic intercept events, but methodologies for collecting high fidelity target damage data have not been perfected. The LFT&E strategy for PAC-3 relies on correlating detailed damage predictions and measurements from ground based testing to validate lethality models. Lethality estimates for realistic intercept conditions, based on these models, are then compared to more limited flight test lethality data. Establishing clear confidence bounds in this process remains a limitation on the PAC-3 LFT&E program.

## VALUE ADDED

DOT&E emphasizes the incorporation of operational conditions in testing scenarios. In the case of PAC-3, DOT&E has been pressing the program office for the use of simulation-enhanced live missile firings using the Flight Mission Simulator to test many-on-one, threat to interceptor ratio scenarios. This type of testing, referred to as Sim-Over-Live, has to overcome some distinct challenges, including safety and test realism. As a result of DOT&E's efforts, those challenges have been met and Sim-Over-Live testing has been incorporated into the flight test program.

## RECOMMENDATIONS

The developmental test failures of the sub-scale, full-body interceptor and sled at the Holloman High Speed Sled Test Track test facility provided insights to the dynamics of high speed testing. It is recommended that these insights be applied to other ballistic missile defense programs, as appropriate.

After firing the non-production represnetative missiles, the remaining Engineering and Manufacturing Development production representative PAC-3 flight test missiles are inadequate to support a legitimate suitability and effectiveness evaluation. The limited flight testing with a production representative missile, coupled with the proposed deferment of testing against several of the critical elements in the Operational Requirements Document (ORD) make a full rate production decision unsupportable at the planned MSIII. DOT&E is recommending that the Department continue at Milestone III with low rate production options, until a follow-on flight test program provides an adequate production representative test database for the complete ORD requirements. Favorable results from this follow-on testing would then support a full production decision.